Software Engineering 2004 – A Jewel in the ACM/IEEE-CS Curricula Effort

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Abstract. We outline the ACM/IEEE-CS sponsored Computing Curricula project, and then discuss the context and development of its Software Engineering Volume (SE2004).. We then discuss evaluation of the volume, internationalization, the relationship with other disciplines, and the importance of the document's future evolution.

1 Introduction

The last five years have seen a major international achievement in computing education. This has been the production of a set of curriculum volumes for undergraduate programs by the Association for Computing Machinery (ACM) and the IEEE Computer Society (IEEE-CS). These volumes address the broad field of computing including Computer Science, Software Engineering, Computer Engineering and Information Systems.

The work commenced in 1998 with an analysis of the existing Computing Curricula 1991 (CC'91) [1], which was also sponsored by the ACM and IEEE-CS. A survey of educators was conducted as part of the analysis. This early work resulted in the decision to divide the curricula into several volumes, each focusing on a particular computing discipline. So far, five discipline volumes have been produced plus an overview report. The Computer Science volume (CS2001) was published in December 2001, followed in 2002 by the Information Systems volume (IS2002). The Software Engineering volume (SE2004) and the Computer Engineering volume (CE2004) were both published in 2004. The latest version of

the Overview volume, currently known as Computing Curricula 2005 (CC2005), and the Information Technology volume were available in draft form in September and October 2005 respectively. All the volumes can currently be accessed via the education web-site of the ACM [2]. The Computer Science volume, the first in the series, contains not only the material relevant to computer science but also some details of the overall project. Updated information on the latter appears in the Overview volume.

It is our opinion that the volume on Software Engineering (SE2004) [2] along with supporting material in the Overview volume, will have a particularly large impact. We believe that SE2004 will act as a catalyst for the development of more and more software engineering programs and should ensure that there are standards and consistency not just within individual programs but also among programs at different educational institutions, across countries, and around the world. We have no doubt that the production of this volume will be recognised in the future as a watershed both in software engineering education and in the maturity of the software engineering discipline. In Sections 2 and 3 of this short paper we provide outline details of the development and content of SE2004. Then in Section 4 we discuss such issues as how SE2004 was evaluated, its international scope, and our view of how it should evolve.

2 The development of SE2004

The project to produce SE2004 has been supported by four main groups of volunteers: a Steering Committee, an Advisory Board, an Education Knowledge Area Group responsible for defining and documenting a body of knowledge known as the Software Engineering Education Knowledge (SEEK), and a Pedagogy Focus Group responsible for using the SEEK in the development of appropriate undergraduate curricula and the definition of undergraduate software engineering courses/programs. The effort was ably led by Rich Leblanc (for the ACM) and Ann Sobel (for IEEE-CS). Further details of all volunteers involved can be found on the project web site [3]. The guiding principles adopted for the volume [2] emphasised that to be successful, the process of creating SE2004 must include participation by as many interested parties as possible, including not only educators but also business and government professionals. It was also of the highest importance to ensure that there was a fully transparent process open to scrutiny by the community. In the end, well over 100 volunteers participated both as contributors and reviewers. In addition, the development involved:

- Public reviews by the software engineering community
- Invited reviews by recognised experts in the field.
- Presentations at conferences to keep the community informed, and to seek input.
- A major invited workshop in Chicago to support definition of the SEEK.
- Articles in community publications, such as FASE and ACM SIGSOFT Software Engineering Notes, to inform the community (e.g., [4] and [5]).
- Open meetings and workshops at major conferences to provide information, carry out activities, and provide feedback. Many of these have been formally reported in detail (e.g. [6]).

3 An overview of the content of SE2004

The body of SE2004 [2] consists of eight chapters: 1: Introduction, 2: The Software Engineering Discipline, 3: Guiding Principles, 4: Overview of Software Engineering Education Knowledge, 5: Guidelines for SE Curriculum Design and Delivery, 6: Courses and Course Sequences, 7: Adaptation to Alternative Environments, and 8: Program Implementation and Assessment. These are followed by an extensive bibliography and two appendices that provide detailed descriptions of proposed courses (A), and lists of contributors and reviewers (B).

Essentially the volume consists of four logical parts. The first, comprising chapters 1 to 3, provides contextual information. This includes background on the SE2004 effort itself, expositions on aspects of software engineering (the discipline, its role as an engineering discipline, and the importance of professional practice), and the principles that underpinned the project.

Chapter 4, presenting the Software Engineering Education Knowledge (SEEK), forms the second logical part. The SEEK is divided into 10 *Knowledge Areas* (KAs) that are appropriate to undergraduate education. Each KA is subdivided into *units* and further broken down into *topics*. For each unit, recommended contact hours are given and for each topic a Bloom taxonomy level is given. The KAs are: Computing Essentials, Mathematical and Engineering Fundamentals, Professional Practice, Software Modeling and Analysis, Software Design, Software Verification & Validation, Software Evolution, Software Process, Software Quality and Software Management. It should be noted that these KAs differ from those defined within SWEBOK [7]. The reason is that the latter addresses knowledge appropriate to four years of professional practice whereas SEEK's target is the knowledge required by a new graduate. In the volume SEEK's relationship to SWEBOK is made quite clear.

The third logical part is Chapter 5. This contains a series of 18 guidelines to be considered both by those developing an undergraduate SE curriculum, and those teaching individual courses. The guidelines are grouped under four main headings: 1) Guidelines Regarding those Developing and Teaching the Curriculum; 2) Guidelines for Constructing the Curriculum; 3) Attributes and Attitudes that should Pervade the Curriculum and its Delivery, and 4) General Strategies for Software Engineering Pedagogy. Each of the guidelines is expanded to provide further advice on its application and warnings regarding possible problems that could occur.

The final logical part of the SE2004 document comprises Chapters 6 to 8. These are devoted to the practical aspects of developing software engineering programs. Chapter 6 presents courses and course sequences. A set of example curricula are presented which can be used to teach the knowledge described in the SEEK according to the guidelines described in Chapter 5. Patterns for introductory courses, core software engineering courses, and other courses are discussed in turn. Further details of the courses are given in Appendix A along with mappings to the SEEK. Chapter 7 is devoted to considerations relating to adaptations to alternative environments such as three-year colleges. Finally, Chapter 8 covers issues associated with program implementation and assessment, and in particular issues associated with: curriculum resources and infrastructure, assessment and accreditation issues, and software engineering in other computing-related disciplines.

4 Discussion

The project to produce the SE2004 volume was large and complex, making it appear slow. The time required was both due to the extensive use of volunteers with concurrent responsibilities, and the care taken to ensure that there was a full and transparent development and review process as outlined at the end of Section 2. It is of particular interest to note that all comments received were considered in depth by the relevant steering committee members. Both the comments and feedback on actions taken in response to the comments were permanently recorded on the project website. The standard set for acquiring and responding to public comments, and especially the use made of on-line tools in this process, was formally recognised by the Chair of the ACM Education Board in his annual report following the publication of the volume. He said it set a new benchmark standard for future ACM-sponsored curriculum guidelines [8].

The project is also notable for the efforts made to address the internationalisation issue. A guiding principle for the software engineering volume was that it must strive to be international in scope. Also, the members of the steering committee were very mindful of the adverse reactions to the computer science volume (CS2001) that occurred during sessions devoted to it at the World Conference on Computers in Education (WCCE2001) in Copenhagen in August 2001 [9]. At those sessions charges of a clear US bias were made. In the software engineering effort, not only were reviewers recruited from around the world, but also the steering committee and the Knowledge Area and the Pedagogy Area focus groups had international leadership and membership. Once again, the success in this area was highlighted by the Chair of the ACM Education Board as setting a benchmark standard [8].

One area that often causes consternation is the relationships between software engineering, computer science, and the broader disciplines of engineering. The chairs for the SE2004 volume worked hard to ensure that a balanced perspective always prevailed. They had to be particularly sensitive to the situation in the US where there are still relatively few software engineering programs at the undergraduate level, and where strong computer science and engineering professional communities jostle for influence. However, the work that has been undertaken has resulted in the relationships among the disciplines being more clearly defined. This has been reflected in the overview volume [2] where significant consideration is given to addressing the "spaces" in which of the sub-disciplines lie.

One question remains: what will happen in the future? Some of us believe that the publication of the software engineering volume will act as a watershed that will lead to the development of increasing numbers of software engineering programs producing the type of graduate that industry so obviously needs. These new software engineers will perhaps start to change the world of software, and poor quality will become a thing of the past. Nevertheless, one thing is clear and that is that the software engineering volume cannot be allowed to stagnate. There need to be mechanisms in place that will monitor its use, track the developments that flow from it, and, at appropriate points in time, ensure that it is examined and updated to reflect the ever-changing faces of education and computing.

Acknowledgements and supporting information

Parts of this paper draw from reports and materials that have been produced by members of the steering committee to promote dissemination of information about the volume. We would also like to acknowledge the contributions made by everyone involved in the development of the SE2004 curricula. In addition, it should be noted that during its developmental stages the project was known as CCSE (Computer Curriculum Software Engineering) and that references to this still appear, for example, in the name of the project web site [3].

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